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ONR Basic Research Program: Summary and Bibliographies

Annual Reports 1 and 2 under Grant N00014-96-1-0298
1 January - 31 December 1996
1 January - 31 December 1997

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13. ABSTRACT (Maximum 200 words)

The Office of Naval Research (ONR) sponsored the Basic Research Program, a discretionary grant program for the purpose of giving university laboratory directors freedom to develop and apply their resources to basic research problems of naval relevance, which might not be known or appreciated by others in the community. Program guidelines included (1) involvement of students and faculty and (2) initiation of research in areas that could transition into either core or special research initiative (SRI) programs at ONR.

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1. INTRODUCTION

The subject grant was originally issued on 22 February 1996 in response to Applied Research Laboratories, The University of Texas at Austin (ARL:UT), proposal P-1682 dated 1 November 1995.[1] This grant was funded out of the Office of the Chief of Naval Research (ONR) discretionary block for support of this laboratory as well as the following laboratories: Applied Research Laboratory, Pennsylvania State University (ARL/PSU); Applied Physics Laboratory, University of Washington (APL:UW); and Marine Physics Laboratory, Scripps Institution of Oceanography, University of California at San Diego (MPL:SIO:UCSD). This block is administered by ONR Code 321OA, Dr. Jeffrey A. Simmen. The purpose of the discretionary grant program is to give the laboratory directors freedom to develop and apply their resources to basic research problems of naval relevance, which may not be known or appreciated by others in the community. The guidelines of the program include (1) involvement of student and faculty and (2) initiation of research in areas that could transition into either core or special research initiative (SRI) programs at ONR.

Support for ARL:UT in FY96 was based on eight research problems, funded as shown in Table 1.1.

Table 1.1

Research Project	Principal Investigator	Funding
Modal analysis and multi-mode seismic inversion in layered elastic media	Dr. Eric Smith and Dr. Tom Muir	$40K
Experimental investigation of traveling ionospheric disturbance	Dr. Tom Gaussiran	$65K
Structural acoustics of high ka backwards waves in the target strength of cylindrical shells	Dr. Gregory Kaduchak	$65K

Dynamic adaptive autonomy in multiagent systems	Dr. K. Suzanne Barber	$65K
Porous media combustion	Dr. Janet Ellzey	$30K
Acoustic agglomeration for post-processing of effluent streams	Dr. O. A. Ezekoye	$30K
Identification of fault-induced vibrations	Dr. Joe Thornhill and Dr. Martin Barlett	$65K
High School Apprenticeship Program	Dr. Tom Muir and Ms. Elaine Frazer	$40K

Modification 1 of the grant, issued on 19 May 1996, added $8.5K to support an existing project (the high school apprenticeship project), which is run during the summer months only. Modification 2, issued on 11 October 1996, added $375K to the grant. Modification 3 deobligated $63K and Modification 4 added $25K, for a net reduction of $38K. This deobligation was due to funding cuts within ONR. Modification 5, dated 18 November 1997, changed the principal investigator of this basic research grant to Dr. Gary R. Wilson.

Support for ARL:UT in FY97 was based on seven research problems, funded as shown in Table 1.2.

Table 1.2

Research Project	Principal Investigator	Funding
Ultrasonic and sono-chemical lysogenesis of bacteria	Dr. Shelley Payne and Dr. Tom Muir	$43K
Concept development of a two-state classifier for vehicular signatures	Dr. Douglas Meegan	$43K
Modal analysis and multi-mode seismic inversion in layered elastic media	Dr. Eric Smith and Dr. Tom Muir	$57K

Experimental investigation of traveling ionospheric disturbance	Dr. Tom Gaussiran	$57K
Structural acoustics of high ka backwards waves in the target strength of cylindrical shells	Dr. Gregory Kaduchak	$40K
Dynamic adaptive autonomy in multiagent systems	Dr. Suzanne Barber	$57K
High School Apprenticeship Program	Dr. Arnold Tucker and Ms. Elaine Frazer	$40K

Statistics on projects, students, faculty, etc., for the duration of this grant are shown in Table 1.3.

Table 1.3

ONR "ARL" PROGRAM

Purpose:

- Seed money - new 6.1 research
- Support UT professors and students on problems of naval relevance
- Support High School Apprenticeship Program

Administration:

- Dr. Jeffrey Simmen, ONR 321OA
- Individual ONR project officers
- ARL IR&D coordinator

	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	FY97
$K	133	299	310	348	370	400	400	400	337
Active projects	11	5	6	7	8	7	7	8	7
Students	11	5	6	7	6	8	9	9	6
Faculty	9	4	5	6	4	6	4	4	3

2. RESEARCH RESULTS

The following bibliographical information summarizes the scientific results produced under this grant. We included work that may have begun under the preceding ONR discretionary grant, but was either finished or reported during the subject grant.

2.1 ARCHIVAL PUBLICATIONS

Bibliographical data are presented here, as well as the abstract of each paper that appeared in refereed journals. Also included are publications that have been submitted but are still in the journal editing process.

1. Hackert, C. L., J. L. Ellzey, O. A. Ezekoye, and J. J. Hall, "Transverse Dispersion at High Peclet Numbers in Short Porous Media," Experiments in Fluids **21**, 286-290 (1996).

Transverse dispersion is examined in short ceramic foams for a variety of pore sizes and flow rates. Experiments were performed with a localized smoke source as a tracer and a coflow of air. Digital images were taken of the resulting dispersion patterns, and an approximate transverse dispersion coefficient was determined. A precise dispersion coefficient cannot be defined at these high Peclet numbers (10^6 - 10^8) because the dispersion becomes non-Fickian. Nevertheless, the approximate coefficients are shown to be consistent with the values obtained by other researchers for lower Peclet numbers and longer porous media.

2. Ellzey, J. L., and M. R. Henneke, "The Shock-Vortex Interaction: The Origins of the Acoustic Wave," Journal of Fluid Dynamics Research **21**, 171-184 (1997).

In this paper we discuss the mechanisms responsible for the formation of the acoustic wave when a shock interacts with a vortex. Experimental measurements have shown that this interaction produces a primarily quadrupolar acoustic wave with a strong compression attached to the shock front. We review earlier work which shows that this strong compression is due

to the distortion of the shock. The origin of the quadrupolar component is examined by comparing two-dimensional computations of the shock-vortex interaction to those of an isolated elliptical vortex. The elliptical vortex is similar to the compressed vortex produced when a shock interacts with an initially circular vortex. We concentrate on interactions in which the shock transit time is short. The pressure field of the shock-vortex interaction is compared to that of an analogous isolated elliptical vortex for three cases: a weak shock interacting with a weak vortex, a strong shock interacting with a weak vortex, and a strong shock interacting with a strong vortex. Our results indicate that both shock distortion and vortex compression are important to the formation of the acoustic wave.

3. Hackert, C. L., J. L. Ellzey, and O. A. Ezekoye, "Effects of Thermal Boundary Conditions on Flame Shape and Quenching in Ducts," Combustion and Flame **112**, 73-84 (1998).

Near quenching laminar flames in parallel plate and cylindrical ducts are investigated computationally using one-step chemistry and a two-dimensional finite volume formulation. The effects of varying the heat transfer boundary conditions on the flame shape and propagation speed are examined. Two flame shapes are shown to arise, depending on the channel width and wall heat losses. A quenching criterion is developed for cases of restricted conductive or convective heat loss through the duct walls, and results are compared to the existing theory. As expected, the quenching Peclet number is found to be proportional to the square root of the overall heat loss coefficient. The importance of internal wall radiation and through-wall heat losses to the flame shape and quenching process is also examined and discussed. Radiation inside the channel is shown to inhibit quenching.

4. Leach, S. V., J. L. Ellzey, and O. A. Ezekoye, "A Numerical Study of Reverse Smoldering," Combustion Science and Technology **130**, 247-267 (1997).

In this paper we present the results from a one-dimensional transient model of reverse smoldering. Two-step chemistry that includes oxidative and pyrolytic steps is used. In contrast to many earlier models, local thermal

nonequilibrium between the solid and gas phase was allowed. Radiative transfer was included using the diffusion approximation. The solid energy, solid species, gas energy, oxygen species, and overall mass conservation equations were discretized in space using finite difference techniques and were solved using VODE (an ordinary differential equation integrator designed for stiff equations). The effects of inlet gas velocity, oxygen concentration, mass diffusion of oxygen, radiation, gas phase conduction, and volumetric heat transfer coefficient were studied using this model. Of particular interest were processes which led to extinction of the smolder wave. One example is the observation that the strong coupling between the volumetric heat transfer coefficient and inlet gas velocity modifies the smolder velocity and quenching dynamics of the wave.

5. Henneke, M. R., and J. L. Ellzey, "Re-Ignition of Lean Methane/Air Mixtures in Porous Media," Combustion and Flame, in review, 1997.

A porous burner operating at a steady state can recover from a temporary interruption in the fuel supply. We numerically simulate this problem by first calculating the steady-state temperature and species profiles in the burner, then interrupting the fuel supply, and re-introducing the fuel after some time. We note the porous matrix is cooled by the non-reacting gases flowing through it, and give a characteristic cooling time for the porous matrix. Detailed chemistry is used in the simulations to accurately predict the chemical ignition delay of the mixture. From these simulations we determine the maximum non-dimensional cooling time (τ_{crit}) after which a methane/air mixture ($\phi = 0.7$) will re-ignite in the porous medium. Our results show that, for a wide range of porous medium properties, τ_{crit} is within a fairly narrow range of values.

6. Henneke, M. R., and J. L. Ellzey, "Modeling of Filtrational Combustion in a Packed Bed," Combustion and Flame, in review, 1998.

Filtration combustion involves exothermic reactions within a porous matrix. The combustion of gaseous fuel and oxidizer filtrating through an inert matrix is one example of filtration combustion. Low velocity filtration combustion, in which the speed of the reaction front is less than 1 m/s, differs substantially from homogeneous premixed combustion. In this paper, we

investigate the low velocity filtration combustion reaction of lean methane/air mixtures flowing through a packed bed and compare to experimental results. Our one-dimensional model includes gas phase transport, radiation, interphase heat exchange, and solid conduction. Reaction is represented with a complete methane/air kinetics mechanism. Our results for solid temperature agree well with experiments for a mixture with an equivalence ratio of 0.15. Consistent with the existing theory on filtration combustion, we determined that gas phase transport is not important to wave propagation at this condition. Gas phase dispersion is important only at higher equivalence ratios. Over a wide range of equivalence ratios, the computed wave speeds show the same trends as the theoretical predictions but are generally higher.

7. Hackert, C. L., J. L. Ellzey, and O. A. Ezekoye, "Combustion and Heat Transfer in Model Two-Dimensional Porous Burners," Combustion and Flame, accepted, 1998.

A two-dimensional model of two simple porous burner geometries is developed to analyze the influence of multidimensionality on flames within pore scale structures. The first geometry simulates a honeycomb burner, in which a ceramic is penetrated by many small, straight, nonconnecting passages. The second geometry consists of many small parallel plates aligned with the flow direction. The Monte Carlo method is employed to calculate the view factors for radiation heat exchange in the second geometry. This model compares well with experiments on burning rates, operating ranges, and radiation output. Heat losses from the burner are found to reduce the burning rate. The flame is shown to be highly two-dimensional, and limitations of one-dimensional models are discussed. The effects of the material properties on the peak burning rate in these model porous media are examined. Variations in the flame on length scales smaller than the pore size are also present and are discussed and quantified.

8. Meegan, G. D., H. R. Nelson, M. L. Barlett, and G. R. Wilson, "Analysis of Engine Noise for Application in Predictive Maintenance," J. Acoust. Soc. Am. **101** (5:2), 3029 (1997).

The analysis of radiated sound and vibrational signatures of engines may be useful for monitoring an engine's performance and assessing the need for maintenance. Measurements of the vibrational signatures and exhaust noise produced by normal engines and engines with known faults will be presented along with a corresponding model for engine exhaust noise. The results of power spectral and higher-order spectral processing of the engine noise will be compared and their usefulness as a means of detecting faulty engine operation will be discussed.

9. Morse, S. F., P. L. Marston, and G. Kaduchak, "High Frequency Backscattering by Thick Finite Cylindrical Shells in Water at Oblique Incidence," J. Acoust. Soc. Am. **99**, 2544-45(A) (1996).

Various authors have demonstrated the importance of plotting backscattering amplitude as a function of both aspect angle and frequency for thin cylindrical shells in water. Some interesting features of analogous plots for thick finite cylindrical shells with the frequency range extending above the coincidence region have been investigated. Impulse response measurements taken with an improved PVDF sheet source reveal a backscattering enhancement in the coincidence frequency region for aspect angles in the vicinity of end-on incidence. Though the cylinder was capped, the features of interest appear to be identified with waves on the coupled shell-fluid system. Similar features are present in backscattering computations for a simply supported thick cylindrical shell and they may be useful in high-frequency inverse scattering.

10. Kaduchak, G., and C. M. Loeffler, "Backscattering of Obliquely Incident Plane Waves by a Composite Cylindrical Shell Constructed of Isotropic and Transversely Isotropic Layers," J. Acoust. Soc. Am. **99**, 2545(A) (1996).

Acoustic scattering from a transversely isotropic cylindrical shell excited by an obliquely incident plane wave is examined. The shell is comprised of *N* layers which may be described by isotropic or transversely isotropic material parameters. The present research solves the boundary value problem for a transversely isotropic, infinite cylindrical layer within the framework of exact 3-D elasticity theory. The layers which comprise the shell are connected via a "propagator matrix" which relates the interior and exterior boundary conditions. The backscattering form function is then constructed for several commonly used composite materials which display transverse isotropy. The results for anisotropic shells are compared to results found for isotropic shells with similar parameters. Here, attention will be given to the similarities (and dissimilarities) of the scattering mechanisms that are the chief contributors to the backscattering form function as the degree of transverse anisotropy is increased. Analysis of the scattered waveform through Fourier synthesis into the time domain will also be discussed.

11. Kaduchak, G., and C. M. Loeffler, "Frequency Dependent Classification Cues Resulting from Localized Interactions on a Target Surface," J. Acoust. Soc. Am. **100**, 2854 (1996).

Much work has been done to extract information about a scatterer by analyzing the spectrum of its echo return. Typical applications rely on phase matched circumnavigations of a surface guided wave (a "resonance" of the structure). The present research incorporates high-frequency scattering mechanisms which interact in a small localized area located about the specular points of a curved surface. The scattering contributions from such mechanisms promptly follow the onset of the specular echo in the time signature and are independent of the back side of the scatterer. The mechanisms presented here

include the effects of thickness resonances and "negative" group velocity surface guided waves. It is shown that by temporally isolating the region about the specular return in the backscattered time signature, it is possible to gain information related to the thickness and/or material properties of a scatterer. This is demonstrated both computationally and in experiments involving cylindrical shells and finite surfaces with one- and two-dimensional curvature. The scatterers are constructed from either anisotropic, fiber-reinforced plastics or metals. Experimental results display the ability to probe the thickness of an extended target with high-resolution sonar.

12. Morse, S. F., P. L. Marston, and G. Kaduchak, "High-Frequency Backscattering Enhancements for Thick Truncated Cylindrical Shells in Water at Oblique Incidence," J. Acoust. Soc. Am. **101**, 3043 (A) (1997).

Various authors have shown that the backscattering by a finite thin cylindrical shell at oblique incidence is enhanced when resonance conditions are met for the propagation of a leaky wave on the shell. To explore the backscattering enhancements relevant to high-frequency detection, impulse response measurements were carried out for slender thick cylindrical shells using a broad bandwidth PVDF sheet source, for tilt angles ranging from broadside to end-on incidence. These measurements reveal large back-scattering enhancements beyond the shear wave cutoff angle, which extend to near end-on incidence in the coincidence frequency region. A simple approximation for the phase velocities of several surface waves is used to identify the underlying mechanisms. A broad enhancement feature is shown to result from the axial propagation of the supersonic a_0 leaky Lamb wave. The associated meridional ray radiates a backward directed wavefront having a vanishing Gaussian curvature. Also observable are what appear to be resonance loci associated with the helical propagation of the subsonic a_{0-}.

13. Morse, S. F., P. L. Marston, and G. Kaduchak, "Windowed Displays of Broadband Impulse Response Measurements for Finite Cylindrical Shells," J. Acoust. Soc. Am. **102**, 3131(A) (1998).

Previously interpreted angle-frequency domain displays of impulse response measurements for thick and thin finite cylindrical shells reveal backscattering enhancements due to elastic effects on the cylinder over a range of target tilt angles. Presently, these signatures are examined in the angle-time and time-frequency domains. For selected angles, time-frequency analyses are presented as well as synthetic aperture images for selected apertures. From these it is possible to identify the spatial and angular locations of many of the important elastic contributions. Features associated with a meridional ray, as well as helical rays, have the appearance of originating from the back end of the cylinder. One major elastic response observed at large tilt angles is found below the coincidence frequency.

14. Kaduchak, G., "Observations of Backscattering of Obliquely Incident Plane Waves by Composite Cylindrical Shells Constructed from Isotropic and Transversely Isotropic Layers," J. Acoust. Soc. Am. **102**, 3073(A) (1998).

Acoustic backscattering from finite, composite cylindrical shells in water is examined. The shells are comprised of *N* layers, which may be described by orthotropic or transversely isotropic materials. The present research examines experimental observations of the scattering signatures obtained from obliquely incident plane waves in the mid- and high-frequency regions. Scattering effects are viewed in both the time and frequency domains. Attention will be given to the similarities (and dissimilarities) of the scattering signatures, which are the chief contributors to the backscattering form function as the symmetry axis of the transversely isotropic layers is rotated away from the axial direction. To localize the sources of scattered radiation at oblique incidence, scattering effects are

viewed with high-resolution techniques, which include narrow transmit/receive beams as well as synthetic aperture sonar.

15. Morse, S. F., P. L. Marston, and G. Kaduchak, "High Frequency Backscattering by Thick Finite Cylindrical Shells in Water at Oblique Incidence: Experiments and Calculations," J. Acoust. Soc. Am. **103**, 785-794 (1998).

Impulse response backscattering measurements are presented and interpreted for the scattering of obliquely incident plane waves by air-filled finite cylindrical shells, immersed in water. The measurements were carried out to determine the conditions for significant enhancements of the backscattering by thick shells at large tilt angles. The shells investigated are made of stainless steel and are slender and have thickness-to-radius ratios of 7.6% and 16.3%. A broadband PVDF (polyvinylidene fluoride) sheet source is used to obtain the backscattering spectral magnitude as a function of the tilt angle (measured from broadside incidence) of the cylinder. Results are plotted as a function of frequency and angle. These plots reveal large backscattering enhancements associated with elastic excitations at high tilt angles, which extend to end-on incidence in the coincidence frequency region. Similar features are present in approximate calculations for finite cylindrical shells based on full elasticity theory and the Kirchhoff diffraction integral. One feature is identified as resulting from the axial (meridional ray) propagation of the supersonic a_0 leaky Lamb wave. A simple approximation is used to describe circumferential coupling loci in frequency-angle space for several surface waves. The resulting loci are used to identify enhancements due to the helical propagation of the subsonic a_{0-} Lamb wave.

16. Kaduchak, G., and C. M. Loeffler, "Influence of Material Parameters on the Target Strength of Fluid-Filled Spherical Shells: Calculations and Alternate Filling Fluids," IEEE J. Oceanic Eng. **23**, 26-30 (1998).

Thin fluid-filled spherical shells have been used as passive sonar targets for many years. They possess a large target strength which is highly dependent on the sound-speed mismatch between the fluid contained within the shell and the exterior fluid surrounding the shell. In the past, to obtain the appropriate mismatch, the interior fluid mixture contained chlorofluorocarbons (CFCs). Due to a recent production ban on CFCs, it is necessary to chose alternative fluids. The present research analyzes the backscattering target strength of a fluid-filled spherical shell as a function of several material parameters as a guide to choosing alternative fluids and shell materials. Calculations over a broad range of material values display the target strength dependence on the interior fluid parameters as well as the parameters defining the metallic shell. The range of material values presented here is far larger than any previous study addressing the focusing effects of fluid-filled spherical shells. The results should aid in determining liquid filers and shell materials which yield the maximum possible backscattered returns. Also, several experiments were conducted with stainless steel shells containing a hydrochlorofluorocarbon (HCFC), dichloro-fluoroethane. The results are compared with results found from calculations as well as from other experiments involving shells containing a previously used CFC mixture.

17. Bust, Gary S., Thomas L. Gaussiran II, and David S. Coco, "Ionospheric Observations of the November 1993 Storm," Journal of Geophysical Research **102** (A7), 14293-14304 (1997).

Complementary measurements from three different electron density measurement techniques are presented for the time period of the November 4, 1993, storm. Computerized ionospheric tomography (CIT) data from an array of

nine ground stations operating as part of the mid-America CIT Experiment (MACE 93) is presented along with data from a digital ionosonde operating near the midpoint of the CIT array. Corroborating data from the DMSP satellites are also presented. Taken together the data provide evidence of a strongly disturbed ionosphere with rapid variations of electron density structures in space and time. The CIT data show a deep equatorward surge of the midlatitude trough to nearly 50/deg geomagnetic latitude, while the ionosonde shows dramatic variations in the virtual height of the ionosphere. DMSP data confirm the equatorward surge of the trough and also display a number of sharp latitudinal variations in vertical drift velocities. An interesting occurrence of spread F also occurred during this time period.

18. Jernigan, S. R., S. Ramaswamy, and K. S. Barber, "A Distributed Search and Simulation Method for Job Flow Scheduling," Simulation **68** (6), 377-401 (1997).

Simulation serves as an effective decision support tool in flexible manufacturing systems for understanding and analyzing the effect of changes to the system environment. Due to the variety of situations that have to be evaluated, a generative scheduler for such a system must be more flexible than its realistic equal while still producing detailed and accurate schedules. This research presents a possible solution to this problem and is intended for use in a distributed, reactive, virtual environment. The solution exploits the advantages gained by using multiple processes in a distributed environment to create, simulate, and evaluate possible schedules. The system is designed on the premise that a distributed parallel search and simulation of competing schedules with accompanying heuristics and subgoaling will greatly reduce the search space and control the state space explosion. Moreover, the need for cycle and deadlock detection is eliminated, thereby decreasing the overall complexity and computational requirements.

19. Smith, Amy R., and Kevin B. Smith, "Mode Functions for the Wide-Angle Approximation to the Parabolic Equation," J. Acoust. Soc. Am **103** (2), 814-821 (1998).

The parabolic approximation to the wave equation is examined within the context of normal mode theory. In a layered waveguide, the horizontal propagation constants and modal amplitudes of the field Ψ satisfying the standard parabolic equation (SPE) approximation can be mapped exactly into the amplitudes and wave numbers of the normal modes for the field p satisfying the Helmholtz wave equation. However, this is not the case for certain other parabolic approximations, such as the wide-angle parabolic equation (WAPE) approximation. Approximate mode functions for the WAPE approximation are developed. These mode functions are then used to decompose range-independent sound-pressure fields computed using the WAPE approximation. The resulting modal coefficients and eigenfunctions obtained using the WAPE mode functions are compared with those obtained using standard normal mode theory.

20. Smith, Eric, Preston S. Wilson, Fred W. Bacon, Jason Manning, John A. Behrens, and Thomas G. Muir, "Measurement and Localization of Interface Wave Reflections from a Buried Target," J. Acoust. Soc. Am. **103** (5), 2333-2343 (1998).

It is demonstrated that seismic interface waves on the surface of a natural beach can be used to identify the position of a buried object. For this experiment, the waves were created with a sediment-coupling transducer and received on a three-element horizontal line array of triaxial geophones. The source and its coupling to the medium provided a high degree of signal repeatability, which was useful in improving signal-to-noise ratio. Reception of

all three directions of particle velocity made it possible to augment conventional beamforming techniques with polarization filters to enhance interface-wave components. Reverberation in the beach was found to be large, though, and coherent background subtraction was required to isolate the component of the sound field reflected by the target. Propagation loss measurements provided comparisons of reflected signal power with predictions made previously, and the two were found to agree closely.

2.2 COMPLETED DISSERTATIONS AND THESES

Bibliographical information on these academic documents is presented here. It should be noted that each of the graduates is a U.S. citizen, and each is a potential candidate for a leadership role in the conduct of future naval research and development.

1. Goel, Anuj (M.S., Electrical and Computer Engineering, August 1997). "Representation and Classification of Agent Architectures."

2.3 DISSERTATIONS AND THESES INITIATED

These projects were initiated under the subject contract and are listed below. Some of these may now have been reassigned to other funding sources.

1. Goel, Anuj, "Sensible Agent Testbed Architecture and Simulation Technologies," Ph.D. in Electrical and Computer Engineering.

2. Jernigan, Stephen, "Heterogeneous Knowledge Representations to Support Domain Modeling in the Software Engineering Development Process," Ph.D. in Electrical and Computer Engineering.

3. McKay, Ryan, "Autonomy Level Agreement Language and Specification of Sensible Agent Group Membership," M.S. in Electrical and Computer Engineering.

2.4 PAPERS PRESENTED AT MEETINGS

Titles, authors, and meeting data for papers presented at meetings are listed below. This listing does not include papers presented at meetings which have subsequently been issued as archival papers. Most, if not all, of the papers listed below will also be issued as archival papers. The presentation of scientific papers at meetings is a give-and-take process that enables the authors to receive criticism, comments, and an exchange of information that sharpens the work perspective and its ultimate relevance, prior to submission as an archival contribution.

1. Ellzey, J. L., "The Interaction of a Shock with a Vortex," Seminars in Mechanics, McGill University, Montreal, Canada, 9 February 1996.

2. Hackert, C. L., J. L. Ellzey, and O. A. Ezekoye, "Modification of Premixed Flame Shapes by Thermal Boundary Conditions," Proceedings of ASME Heat Transfer Division, HTD-335(4), 375-382, 1996.

3. Leach, S. V., J. L. Ellzey, and O. A. Ezekoye, "A Numerical Study of Smoldering Combustion," Proceedings of the 1997 National Heat Transfer Conference.

4. Henneke, M. R., and J. L. Ellzey, "Numerical Study of Re-Ignition in Porous Media," Proceedings of the 1997 National Heat Transfer Conference.

5. Hackert, C. L., J. L. Ellzey, and O. A. Ezekoye, "Heat Loss Effects in a Porous Honeycomb Burner," Proceedings of the 1997 National Heat Transfer Conference.

6. Leach, S. V., J. L. Ellzey, and O. A. Ezekoye, "Convection, Pyrolysis, and Damkohler Effects on Extinction of Reverse Smoldering Combustion," submitted to the Twenty-Seventh International Symposium on Combustion, 1998.

7. Meegan, G. D., H. R. Nelson, M. L. Barlett, and G. R. Wilson, "Analysis of Engine Noise for Application in Predictive Maintenance," 133rd Meeting of the Acoustical Society of America, 1997.

8. Barber, K. S., "Adaptive Autonomy: The Key to Dynamic, Responsive Formation of Sensible Agent Organizations," Invited Paper to the Conference on Intelligent Systems and Semiotics, 22-25 September 1997.

9. Barber, K. S., "Sensible Agents," Invited Paper to the IEEE International Conference on Systems, Man and Cybernetics, Orlando, Florida, 12-15 October 1997.

10. Barber, K. S., "The Architecture of Sensible Agents: Modeling and Specification of Systems Capable of Dynamic Adaptive Autonomy," Invited Paper to the 11th International Conference on Industrial & Engineering Applications of Artificial Intelligence & Expert Systems (IEA/AIE-98), Benicassim, Castellon, Spain, 1-4 June 1998.

11. Gaussiran, Thomas L., and Gary S. Bust, "TID Investigation Utilizing CIT and GPS-TEC," 1997 North American Radio Science Meeting, Montreal, Ontario, Canada, 13-18 July 1997.

12. Coker, Clayton E., and Thomas L. Gaussiran, "Emerging Capabilities for GPS as an Ionospheric Sensor," Ionospheric Effects Symposium, Alexandria, Virginia, May 1996.

13. Smith, E., J. Behrens, P. Wilson, B. Wolz, and T. G. Muir, "Seismic Interface Wave Sonar," III Encontro de Technologia em Acustica Submarina, Rio de Janeiro, Brazil, September 1997.

2.5 ARL:UT REPORTS

In addition to the archival papers, dissertations, theses, and other highly valued scientific documents cited above, there is a very real and important need for the publication of a variety of reports that are useful in the conduct of work.

1. Meegan, G. D., H. R. Nelson, M. L. Barlett, and G. R. Wilson, "Fault Induced Machinery Vibrations: Applications to Diesel Engines," Signal Physics Group Report No. 97-10 (GR-SP-97-10), Applied Research Laboratories, The University of Texas at Austin, 1998.

2. Meegan, G. D., M. L. Barlett, and M. A. Donnell, "Development and Evaluation of a Multi-State Classifier for Vehicular Signatures," Signal Physics Laboratory Report No. 99-1 (LR-SP-99-01), Applied Research Laboratories, The University of Texas at Austin, 1998.

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2.6 DoD SCIENCE AND ENGINEERING APPRENTICESHIP PROGRAM

The purpose of the apprenticeship program is to provide outstanding recent high school graduates with hands-on experience in the stimulating research environment and encourage them to pursue careers in the science and engineering disciplines, particularly in those areas related to the needs of the Department of Defense. Students were selected for this program on the basis of their academic records, scholastic aptitude test results, and applications. Each student was assigned to a research project to be performed under the supervision of a research staff member at ARL:UT. At the end of the apprenticeship in mid-August, students gave oral presentations, using visual

aids, for the Laboratories' directors, and prepared short technical papers summarizing their project results. The annual report included technical papers by the following student authors, whose abstracts appear below. Editing of the abstracts was minimal to preserve their originality of expression.

1996 Participants

Katherine Bennett	ITG On-Line Time Sheets
Brian Burgin	Interface Scattering or Slow Wave
William Cain	Coordinating Data Acquisition with Data Analysis: A LabVIEW-MATLAB Interface
Shannon Gibson	Design, Construction, and Calibration of Dolphin Suction Cup Hydrophones
David Linville	Software Configuration Management
Somit Mathur	Three-Dimensional Graphics VRML/Internet Project
Deborah Matzner	Virtual Height Correction of Ionograms
Christopher Mechsner	Transducers for Acoustic Agglomeration
Keiko Petrosky	Summary of Radio Signal Propagation Modeling by Computer Simulation
Anne Pettengill	Improving GPS Accuracy through Analog Sensors
Daniel Prince	Source Level Measurements in the Large Test Tank
Anang Shelat	Adventures in Real-Time Kinematics Positioning and Geographic Information Systems

Abstracts of 1996 Apprenticeship Reports

1. Katherine Bennett. ITG On-Line Time Sheets.

To stabilize the processes and environment in which software development takes place, a process maturity framework, called the Capability Maturity Model (CMM) was developed by the Software Engineering Institute (SEI). This allows an organization to measure the maturity of the software process and evaluate its software process capability. One of the steps is to analyze time metrics, determining how much time is spent on individual tasks.

The current system employed by ARL:UT is ineffective in accomplishing this task. The most effective way to perform this task is by using an on-line, time-recording system. This project was designed to aid in the development of a time-tracking system.

2. Brian Burgin. Interface Scattering or Slow Wave.

In recent years, the growth in coastal operations has yielded an increased interest in the field of underwater research for the construction of a reliable sedimentary acoustic model. Construction of this model has relied heavily upon experimental comparison to the long-standing deep sea model. Since the beginning, however, inconsistencies have appeared between the two models and between the sedimentary model and the general theories of underwater acoustics. Specifically of concern to this project is the previous discovery of slow acoustic waves in sediment which are apparent at shallow grazing angles. Detected and confirmed by four separate groups including one directed by Dr. N. P. Chotiros, these waves represent an anomaly to the general theories of underwater acoustics.

3. William Cain. Coordinating Data Acquisition with Data Analysis: A LabVIEW-MATLAB Interface.

This report describes the results of a project to develop an interface between two software packages, one that acquires data and one that analyzes it. The acquisition package is the LabVIEW graphical programming language; the analysis package is the MATLAB scripting language. A demonstration was also set up to serve as an example of the interface system; this demonstration involved the acquisition and analysis of geophone data. The outcome of the project was the development of two methods by which data acquisition and analysis are coordinated.

4. Shannon Gibson. Design, Construction, and Calibration of Dolphin Suction Cup Hydrophones.

Under contract with the Office of Naval Research and in cooperation with Texas A&M University, Ph.D. candidate Diane J. Blackwood, Applied Research Laboratories, The University of Texas at Austin, was asked to determine if there are significant nonlinear components on dolphin biosonar. For nearly 50 years these marine mammals have been known to use echolocation, or "biosonar," but the extent of their ability has yet to be resolved. My contribution to this project entailed helping to design, construct, and calibrate different hydrophones that could be used to acquire sonar data from the dolphins.

5. David Linville. Software Configuration Management.

This project involved the AN/BQS-15 EC-18, a revision to the sonar system installed in 688 class submarines. AN/BQS-15 is the Navy designation for the sonar, and EC-18 signifies that it is the eighteenth engineering change, or revision, on the sonar. The primary purpose of this sonar is to provide the submarines with a better system of detecting mines and other dangers, such as ice keels. It also has a more limited role in antisubmarine warfare and in gathering acoustic intelligence. The major goal of the current change is to improve the sonar's reliability and to add new computer-aided detection functionality.

6. Somit Mathur. Three-Dimensional Graphics VRML/Internet Project.

The purpose of this project was to create a virtual reality modeling language (VRML) viewer. This required me to understand and code in C++ with the OpenGL graphics library and to understand the general principle of the Internet and its wide usage utilizing applications on the Web. The program

applied to the Internet consists of a VRML viewer and parser to read data from an input VRML text file.

7. Deborah Matzner. Virtual Height Correction of Ionograms.

At the beginning of this summer project, the ionosonde had been making soundings for many years, but the problem with the virtual heights in the ionograms had not been addressed. Soundings had been made and archived, but no program had been applied to convert to real heights. Ionosondes are one of many ways in which people can study the ionosphere. Others include study of the phase of signals received from satellite sources. Ionosondes map the local ionosphere directly overhead and show daily fluctuations in the electron density profiles, as well as unusual fluctuations caused by solar activity. The purpose of this project was, in addition to maintenance of the ionosonde and assistance to others working with the ionosonde, to get the output of our ionosonde into the program POLAN and to make the program POLAN usable on ARL:UT's ionosonde database. This would allow correct measurements of the height of the local ionosphere.

8. Christopher Mechsner. Transducers for Acoustic Agglomeration.

The objective of this project was to construct two new sound sources that will be energy efficient, easily moveable, and relatively cheap. The sound sources must also be easy to run and must be able to produce a loud and high frequency sound extended over a long period of time. The purpose of researching acoustic agglomeration is to successfully agglomerate fly ash (burnt coal) in major industries that produce pollution. The Navy is also very interested in acoustic agglomeration for the reduction of pollution in their big diesel engines, which power so many of their enormous boats and battleships. In the future, acoustic agglomeration could also be used in the reduction of pollution produced by automobiles.

9. Keiko Petrosky. Summary of Radio Signal Propagation Modeling by Computer Simulation.

Sophisticated computer programs are used to make signal propagation path predictions. These models currently consider variable atmospheres, terrain, and antenna configurations. Because each of these factors greatly affect the signal propagation path, it is essential that we understand the limitations and strengths of models used in current operating systems. We conclude that VTRPEW is the most accurate and most time consuming of the models studied and that the approximations made by RPO and TPEM prove accurate in most scenarios. However, RPO results differ from the other models in atmospheres that vary with range. Moreover, atmospheres should not be preprocessed by RSMA.

10. Anne Pettengill. Improving GPS Accuracy through Analog Sensors.

The Global Positioning System (GPS) is the world's doorway to accurate determination of position, velocity, and time. Since its inception in the 1970's, there has existed a constant effort to improve the accuracy, robustness, and efficiency of this technology. Kinematic GPS surveying allows positioning of dynamic platforms with accuracy in the 0.5- to 3-cm range. The purpose of this research is to evaluate how analog sensors can be combined with GPS to enable even higher positioning accuracy.

11. Daniel Prince. Source Level Measurements in the Large Test Tank.

A great amount of time and energy is often expended to find a suitable site for the procedure of determining the source level of an object. Expensive trips to large lakes or to the ocean are made because of the inability to find a reliable procedure for testing in smaller water sources. Applied Research

Laboratories' large test tank would provide a convenient, cost-effective site for taking sound source level measurements if a dependable method of taking those measurements could be found. The purpose of this project was to further the development of a technique and determine its reliability in the large test tank by finding the free field monopole intensity at 1 meter radius and then converting that intensity to the equivalent mean square pressure.

12. Anang Shelat. Adventures in Real-Time Kinematics Positioning and Geographic Information Systems.

The Defense Mapping Agency (DMA) Survey Divisions, the Department of Defense's primary warehouse of geographic information, is supported by three branch offices at Holloman Air Force Base in New Mexico, Patrick Air Force Base in Florida, and Edwards Air Force Base in California. However, because no viable network for geospatial data transport had been established, the DMA divisions have been unable to share information with each other or with outside agencies. Thus, the agency's enormous capacity for spatial analysis remained untapped. As a result, the DMA established a contract with ARL:UT to introduce measures to help reduce communication barriers and facilitate the application of geospatial data. The Geomatic Systems Division (GSD) at ARL:UT determined that the implementation of a geographical information system (GIS) was the best solution to this problem.

1997 Participants

Gregory Alexander	Using Threads to Accelerate Database Access in OBDIF and Other Multiple Database Applications
Alex Chen	Measuring the Roughness at the Ocean Bottom
Amy Chen	Developing and Integrating a Barcode Collection and Management System into the Integrated Missile Processing System

Garrett Evans	Conditioning Monitoring of Electrical Machinery through Power Supply Measurements
Andres Flores	Analysis of Critical Error Sources in GPS Structural Monitoring
Daniel Harding	A Software Package to Animate Undersea Audio Propagation
Anita Lillie	Computer-Aided Detection of Mines
Stephanie Ng	The Cracking of an Oyster: Discovering Perl
Roy Paterson	The Automated Vehicle Classification System: The Simulation Approach to Understanding Seismic Vehicle Signals
Pamela Pontius	The Power System of the TRANSIT Satellites
James Railey	The TRANSIT Satellite Constellation: History and Reactivation
Neal Tanner	Facilitation of Testing of HFSP
Brian Watkins	Multi-Platform Documentation and Generation Maintenance

Abstracts of 1997 Apprenticeship Reports

1. Gregory Alexander. Using Threads to Accelerate Database Access in OBDIF and Other Multiple Database Applications.

In order to take advantage of today's new computers with multiple processors, software must be developed with such operation in mind, through constructs such as multi-threading. For database programming, information often must come from several sources in order to acquire the full range of available information. In such database situations, speed becomes an important factor. Does multi-threading offer a significant improvement over more sequential methods of database access? The purpose of this project was to answer this question in a general sense as well as to attempt to apply this concept to the OBDIF project specifically.

2. Alex Chen. Measuring the Roughness at the Ocean Bottom.

Sonar systems are highly sensitive to many factors in the ocean. One important factor is the roughness of the sea bed. During the past two months, I have built underwater containers for a camera and a laser, two pieces of equipment that will measure and record the roughness at the bottom of an indoor tank. I have also learned how to use the program Interactive Data Language (IDL) to process and analyze the camera's images.

3. Amy Chen. Developing and Integrating a Barcode Collection and Management System into the Integrated Missile Processing System.

IMPS is an effort to implement an integrated system of processes and data across all areas related to missile production and maintenance. Although such an undertaking is obviously a long-term goal, this ARL:UT team meets regularly with its sponsor (Special Projects 273) to discuss and demonstrate progress and the fulfillment of certain goals made up to that point. Because bar-code software and hardware was an area in which little progress had been made, I focused primarily on integrating a functioning hand-held barcode scanner into the existing IMPS architecture. The scanner would be responsible for the input of all barcoded part information (such as part numbers, serial numbers, model numbers, lot numbers, etc.) for each part described in the Lockheed Martin Work Instruction. In addition, I also worked with an HP keywand to allow for badge ID scanning at the workstation.

4. Garrett Evans. Conditioning Monitoring of Electrical Machinery through Power Supply Measurements.

The world of big industry depends greatly on the function of large electrical machinery. When this machinery breaks down, an abundance of time, efficiency, and, subsequently, money is lost to (1) the breakdown itself and (2)

the time that is taken to find and repair the fault that caused it. A system with the ability to detect and recognize these faults during machine operation could potentially decrease many of these losses by eliminating the fault identification process and, depending on the fault, allow a shutdown time to be scheduled in which the fault can be repaired. The purpose of the project I have worked on this summer has been to research a particular method of such condition monitoring. This method is the measurement and observation of changes in the power supply to the motor driving the machinery. Arvind Thirunarayanan (University of Texas at Austin student and Applied Research Laboratories Honors Scholar) and I have worked on the project dually under the supervision of Horacio Gasquet.

5. Andres Flores. Analysis of Critical Error Sources in GPS Structural Monitoring.

One of the applications of the Global Positioning System (GPS) is precise mm-level structural deformation monitoring. This paper, which summarizes efforts performed during the High School Apprenticeship Program at Applied Research Laboratories, The University of Texas at Austin (ARL:UT), focuses on the effect and mitigation of critical error sources for GPS deformation monitoring at the Holloman High Speed Sled Test Track (HHSSTT). The analysis indicates that specific techniques can measurably reduce the effects of multipath and tropospheric delay in this application.

6. Daniel Harding. A Software Package to Animate Undersea Audio Propagation.

In studying undersea audio propagation, the ARL Environmental Sciences Group (EVG) makes use of an acoustic propagation model called ORCA. This program outputs its propagation data as a function of three variables: receiver range, receiver depth, and time. Software exists for

visualizing this output, but it is limited to displaying only two of the three dimensions effectively. My task this summer was to write a software package that would allow all three dimensions to be visualized through animation. In addition, I wrote software that enhanced both ORCA and the existing visualization software.

7. Anita Lillie. Computer-Aided Detection of Mines.

The U.S. Navy often detects long-range underwater targets (mines) by analyzing sonar readings through computer-aided detection (CAD). Shoreline areas are highly populated with clutter, which typically results in high false alarm rates in the detection stage of sonar sea tests. Much of the clutter returns target-like readings and therefore causes many unnecessary target calls to classification and/or identification stages. Changes and additions to the code at the detection stage can significantly reduce the number of target calls propagated for classification and identification. The goal of detection algorithm improvement is to maintain the probability of detection while reducing probability of false alarm.

8. Stephanie Ng. The Cracking of an Oyster: Discovering Perl.

After the creation of a database which tracked ITG software licensing and compliance, a search engine was created so Web users could more easily acquire the record. A submission form allowed for editing via the Web. The programming language used in generating the search engine and submission form was the Practical Extraction and Report Language, or Perl. The Hypertext Markup Language, or HTML, prepared the hypertext documents to distribute on the World Wide Web and acted as an interface for the CGI script.

9. Roy Paterson. The Automated Vehicle Classification System: The Simulation Approach to Understanding Seismic Vehicle Signals.

The Automated Vehicle Classification Project is an attempt to develop a system that is capable of remotely and automatically identifying an unknown vehicle. Such a system would be of great use in monitoring traffic in remote locations or at times when stealth is necessary. The Texas Border Patrol has expressed much interest in this project, as they would like to use it to monitor remote roads. Other possible sources of funding include the Military and the State of Texas. An Automated Vehicle Classification System (AVCS) would use as many input channels as possible. These could include audio, video, electromagnetic, and seismic sensors. The AVCS would then process the incoming data to extract features that would be useful in identifying the vehicle (number of gears, number of axles, etc.). Finally, the AVCS would have a large database of all known vehicles and their features. It would compare the observed features with its database and make a positive identification.

10. Pamela Pontius. The Power System of the TRANSIT Satellites.

The Navy developed the TRANSIT satellites in the early sixties for submarine navigational purposes. As the technology available to the general public increased, private boat owners also employed these satellites to determine their position at sea. However, this navigational use, dwindling down since the implementation of the Global Positioning System (GPS), halted completely in December of 1996. The Applied Research Laboratories at the University of Texas (ARL: UT) is currently involved in monitoring the health of these satellites. The power system, one area of focus of health maintenance check, controls all functions of the satellites. Many different aspects of the internal satellite workings, such as current, temperature, and voltage, must stay within certain limits to maintain the optimum efficiency and stability of the

satellite. This paper takes a broad look at how OSCAR 23, a TRANSIT satellite launched in 1988, is currently functioning.

11. James Railey. The TRANSIT Satellite Constellation: History and Reactivation.

My summer project involved research on the Navy Navigation Satellite System, or TRANSIT. I also created a theoretical plan for the reactivation of one of the OSCAR-type TRANSIT satellites. The assigned tasks included researching and cataloging all information I could find on the OSCAR-type TRANSIT satellites, learning about predicting satellite orbits, creating a plan for reactivation for one of the inactive OSCAR-type satellites, and creating a presentation and report on the summer project.

12. Neal Tanner. Facilitation of Testing of HFSP.

Previous to my arrival at ARL, HFSP had established a differential global positioning system (DGPS) station on the hill above LTTS. A DGPS unit with bottom sounding capabilities had been installed on one of the research ships, the Sea Arc. This setup proved to be capable of two-meter accuracy through the use of correction factors transmitted via 5-watt free wave radios from the DGPS station to the unit on the boat. Using this setup, the area of Lake Travis in front of LTTS had been surveyed to generate a topographical map of the lake bottom in the Universal Transverse Mercator (UTM) grid. This project further developed the capabilities of the DGPS unit.

13. Brian Watkins. Multi-Platform Documentation and Generation Maintenance.

Documentation and on-line help exist for the purpose of conveying requested information to the user. A crucial element toward achieving this end

is the identification and separation of different categories of information. A comprehensive suite of documentation will include resources in several different formats. Unique problems arise in both the generation and maintenance of multi-platform documentation. A successful solution will depend on both consideration of project-specific details and on the application of more general principles.

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8 January 1999

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